Journal of Power Sources, *33* (1991) 87–92

Application of wrought lead–calcium batteries in Europe*

M. D. Achtermann and **M. E. Greenlee**
Delco Remy Division, GMC, 2401 Columbus Avenue, Anderson, IN 46018 (U.S.A.)

Abstract

Use of lead–calcium batteries in automotive applications offers definite advantages in the areas of overcharge, high temperature, water usage, and self-discharge. The Delco Freedom battery with wrought expanded grids additionally provides increased resistance to corrosion. Customer satisfaction with the sealed, maintenance-free battery has been well established in the field. Still to be recognized are some aspects of static testing in the laboratory. This technology is now poised for the future by offering battery location flexibility in the vehicle and meeting the no maintenance expectations of the customer.

Introduction

In 1970, Delco Remy introduced the first sealed maintenance-free battery into the U.S.A. in the Pontiac Grand Prix passenger car. Design and testing had started ten years earlier. In 1975, the heavy-duty maintenance-free battery was introduced for the trucking industry. By 1978, the total North American Delco battery manufacturing capacity was converted to lead–calcium design. In addition, Delco Remy chose to include in the Freedom battery the expanded grid made from wrought lead–calcium–tin strip in order to offer optimum protection against overcharge and positive grid corrosion.

Since the first introduction, 150 million Freedom batteries have been produced in Delco Remy's six North American plants. In 1980, production started in a new plant in Sarreguemines, France, and the sealed maintenance-free battery was introduced in Europe. To date, some 18 million automotive and heavy duty batteries have been sold in Europe.

Extensive field testing in the U.S.A. under a wide range of temperature and service extremes showed the low water usage of the lead–calcium system to be a 'fact of life'. These early tests, prior to introduction, demonstrated that the battery could be sealed to provide maintenance-free service and offer normal and even extended life in the vehicle.

Today, the lead–calcium battery is performing well in Europe and provides the vehicle user with advantages not offered by conventional

*Paper presented by Jean Bonnet, Delco Remy Division, GM France, BP 819, 57208 Sarreguemines Cédex, France.

0378-7753/91/$3.50

lead–antimony technology. The vehicle manufacturer and aftermarket consumer have a wide range of battery technology to choose from: conventional lead–antimony, low antimony, hybrid and lead–calcium. The lead–calcium batteries offer the choice of cast grids or expanded grids. Experience with the Freedom maintenance-free battery is reviewed in this paper and some suggestions are made for testing requirements in the laboratory.

Development of the Freedom battery

During the evolution of maintenance-free batteries, various levels of grid antimony content were investigated. Eventually, the lead–calcium alloy system was chosen. The benefits offered by the lead–calcium system are well-known to those in the battery industry: resistance to overcharge; resistance to thermal runaway at elevated temperatures; low self-discharge; low water usage (Fig. 1).

At this point, the ideal grid had been achieved except for two problems. The cast lead–calcium grid had poor corrosion resistance and was difficult to manufacture because of the lack of strength in freshly cast grids (Fig. 2). The cast grid was therefore abandoned and work was commenced on wrought lead–calcium, produced by rolling a thick slab of the alloy down to a thin strip. The rolling process defines the grain structure and work hardens the alloy, thus providing improved corrosion resistance along with added strength for handling. When this strip is then expanded to form the lead–calcium grid, all the previously-mentioned benefits are achieved as well as excellent corrosion resistance (Fig. 3).

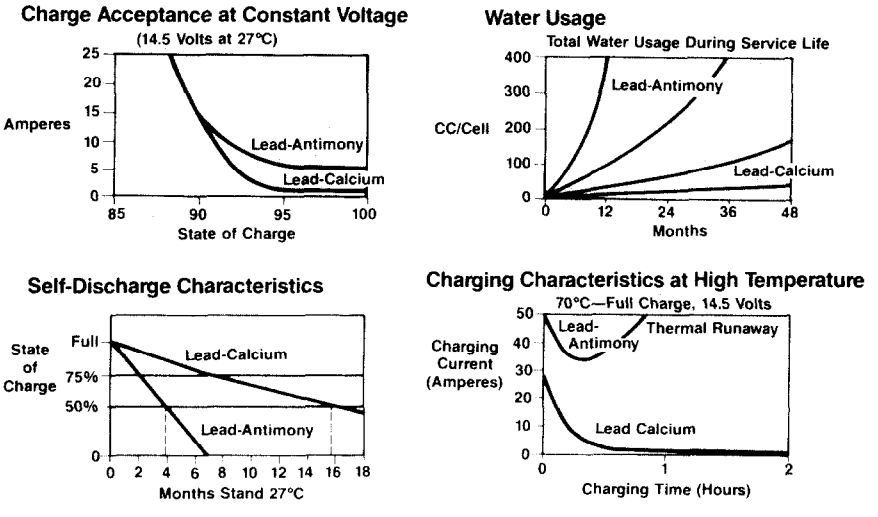

Fig. 1. Advantages of non-antimony grid technology.

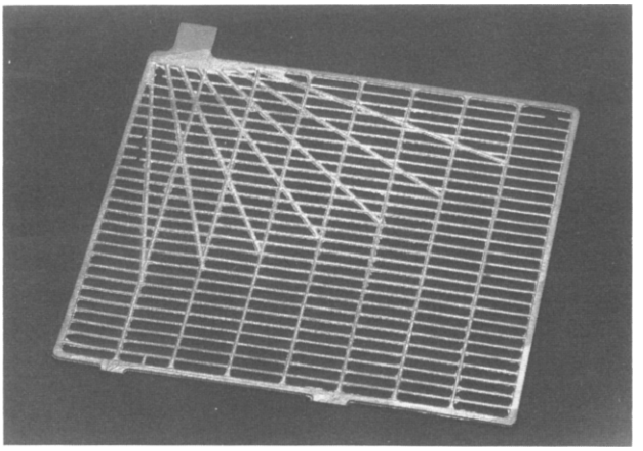

Fig. 2. Cast lead–calcium grid.

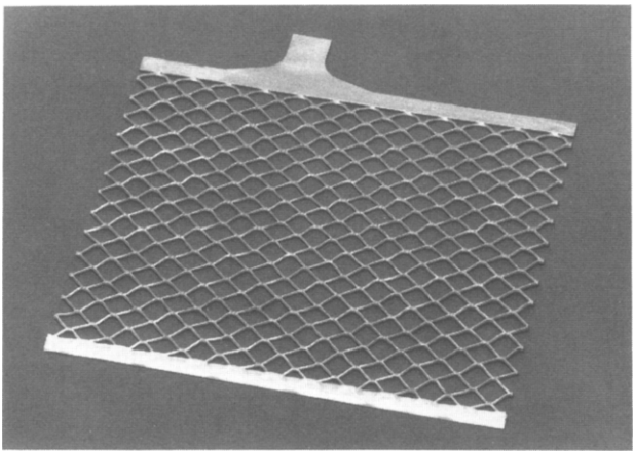

Fig. 3. Wrought lead–calcium expanded grid.

The maintenance-free technology of the Freedom battery has been well proven over time and continues to evolve, addressing the changing needs of the customer. The ever-growing list of Freedom battery applications shows acceptance and customer satisfaction in Europe (Table 1).

TABLE 1

Freedom battery: European customers

Opel	Esso	OK
Vauxhall	Caterpillar	Alfa Romeo
Peugeot	Deltec	Fiat Iveco
Citroen	Den Ouden	Lotus
AC-Delco	RVI	Ferrari
	Volvo Truck	

Battery charging

The advantages offered by the antimony-free system have been listed above. Among these were resistance to overcharge and thermal runaway. The higher countervoltage of the lead–calcium battery compared with the conventional antimonial battery that provides these very desirable characteristics is often misunderstood in the laboratory testing of batteries. It is therefore important to discuss static performance testing, particularly battery charging in the laboratory.

Traditional battery charging prior to running a laboratory test has been conducted using one of two methods. The first is constant current, requiring charging until consistent specific gravity readings are obtained, or intentionally overcharging by a predetermined amount to assure 100% state-of-charge (SOC). The second method is constant voltage. Constant voltage recharge is an easier method from the standpoint of not requiring specific gravity monitoring. This latter method also avoids overcharging while bringing the battery to 100% state-of-charge.

The main concern with constant-voltage recharge is using the proper voltage and current limits to adequately complete the process. Many constant-voltage specifications have been written using voltage limits previously established for lead–antimony batteries, typically 14.8 V at 27 °C. This voltage is higher than would be experienced in vehicle applications, but is necessary to achieve full recharge for static testing in the laboratory. The same is true of lead–calcium batteries when charging and testing in the laboratory.

It is recommended that all Freedom batteries be changed at 16 V for 24 h with a 25 A current limit. This guarantees complete recharge with voltage and current levels sufficient to minimize acid stratification, which is unique to static laboratory charging, as well as reduce variation in test results. It is also recommended that batteries undergo a 24 h stand after charging and before being placed in a coldbox for a cold-rate discharge. This stand ensures adequate de-gassing and removal of the gas bubbles that form on the plate surfaces during static laboratory charging. Without this stand, test results will be variable and subject to the resistance effects of this surface phenomenon. Variations in the region of 5% for the 30-s voltage and 10% for the runtime to 6 V can be eliminated.

The use of a higher charge voltage for testing lead–calcium batteries in the laboratory has been misinterpreted to imply charging problems in vehicle applications. The voltage used in the laboratory is not related to the ability of the battery to operate satisfactorily in passenger cars with normal voltage regulator settings.

In order to demonstrate the ability of Freedom batteries to maintain a satisfactory SOC with normal voltage regulator settings, a significant amount of field data has been gathered. Numerous surveys have been conducted in Europe over the past several years, both in winter and in summer. Various sites were used to gather a meaningful comparison of Freedom

batteries and conventional lead–antimony batteries. The survey results show the Freedom battery is maintained at a satisfactory SOC in normal passenger car applications and compares very favorably with lead–antimony batteries. Overall, the Freedom battery SOC was in excess of 87%, while that for the lead–antimony batteries was approximately 80% (Table 2).

Battery durability

Durability and life comparison information has been gathered from some independent sources. This also demonstrates that Freedom batteries meet the needs of the customer.

In 1982, comparative testing was done in Frankfurt, F.R.G. taxi applications using Freedom and conventional batteries. As reported in *Taxi-Journal*, the Freedom (battery exhibited superior life in this application. Conventional batteries began to fail two years into the test, while the Freedom batteries lasted well into the third and fourth years.

In 1986, Michelin Tyre in the U.K. used ten vehicles equipped with Freedom batteries for two years of tyre testing. At the end of the two-year period, all ten batteries were still in service for an average of 286 000 km.

In 1986, Hertz Leasing of Europe reported data from their 20 000 vehicle fleet. After 75 000 km, 43.2% of the Austin batteries and 29.7% of the Ford

TABLE 2

European state-of-charge (SOC) surveys

Season	Date	Site	Battery type			
			Delco Freedom		Conventional	
			No.	Average SOC (%)	No.	Average SOC (%)
Winter	Jan. 84	Germany	200	86.9	26	81.3
		France	69	86.8		
	Feb. 86	Germany	201	86.4	108	81.7
		France	72	87.6	35	78.4
		U.K.	85	86.8	75	79.7
	Jan. 87	Sweden	60	86.5	40	74.6
		Germany	150	88.2	62	80.2
		U.K.	75	87.6	40	79.4
Summer	Aug. 84	Germany	138	90.9	80	81.5
		France	42	92.6		
	Aug. 85	Germany	235	88.2	102	79.1
		France	86	92.2	17	70.6
	Jul. 86	Germany	180	89.7	72	81.7
		France	102	91.0	75	82.4
	Jul. 87	Spain	175	90.7	87	78.8
		France	120	92.1	75	80.7

batteries had failed, while only 5.8% of the Freedom batteries in Vauxhalls were reported as having problems.

From the preceding data, it is not only evident that the Freedom battery can be charged in the normal vehicle application, but it also offers superior durability and reliability to today's consumer.

The future

The lead–calcium battery is very well positioned for tomorrow's vehicle and customer needs. As we move into the 1990s, there continues to be a trend towards higher under-the-hood temperatures. The Freedom battery's resistance to overcharge and thermal runaway has become more beneficial than ever before. Temperature extremes are being driving up by hood profiles coming down for aerodynamics and styling. In addition, engine compartments are being enclosed to reduce drive-by noise. These changes reduce air flow into and through the engine compartment.

The maintenance-free characteristics of the Freedom battery allow for mounting flexibility. Because no water addition or periodic terminal cleaning are necessary, batteries can be placed in inaccessible areas. Customer expectations of maintenance-free vehicles are also enhanced by a battery that can be installed and forgotten.